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Observations on three-dimensional measurement of confined fission track lengths in apatite using digital imagery

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Abstract

We report the results of a comparative study to explore the usefulness of 3D measurements of confined fission track lengths (TINTs) relative to horizontal confined track length measurements (dips ≤10°), and evaluate their suitability for thermal history modeling. Confined fission track lengths were measured in 10 annealed Fish Canyon Tuff apatites containing synthetic mixtures of different length components, and two Durango apatites containing spontaneous fission tracks. Measurements were primarily carried out using a digital image-based microscope system, and they were compared to those from a regular optical drawing tube-digitizing tablet setup, and a confocal laser scanning microscope. The results indicate that 3D measurements of confined track lengths are closely comparable to conventional horizontal track measurements, and the mean track lengths of inclined (dips >10°) and horizontal (dips ≤10°) confined tracks from the one sample are equivalent within the measurement uncertainty. A strong dip-bias was observed, so that almost all the confined tracks measured were dipping at <30°, and the great majority (~70%) were dipping at ≤10°, thereby qualifying as "horizontal" confined tracks. Our results suggest that a useful increase of more than 40% in sample size can be achieved from including dip- and refraction-corrected 3D track length measurements. Some evidence was seen for a small bias in favor of shorter tracks at higher dip angles but this has very little influence on the mean lengths or length distributions up to the practical limit of dips (~30°) observed in these measurements. Results obtained using the same measurement system by a single analyst over time and between six different observers in the one laboratory show good reproducibility. These results also agree well with conventional horizontal confined track length measurements in the same samples in the second laboratory involved. We conclude that 3D measurements of confined track lengths, including both horizontal and inclined tracks, are suitable for use in current fission track annealing models derived from experiments using horizontal confined tracks.

Keywords: Thermochronology, fission track dating, apatite, confined track lengths, 3D measurement, digital imaging